Putnam Lake Dredging Feasibility and Sediment Monitoring

To:	Mr. Richard Williams
From:	Luke Gervase, CLM and Project Manager
c:	Alejandro Reyes, CLM, Mary Beth Billerman, Senior Ecologist and Permitting Specialist, and Lindsey Kollmer, Aquatic Ecologist
Date:	April 2024
Re:	Putnam Lake Dredging Feasibility Town of Patterson Hamlet of Putnam Lake, NY GEI Project No. 2303651

GEI Consultants Inc., P.C. (GEI) is pleased to present this dredging feasibility sediment monitoring memo for the Town of Patterson (TOP).

Project Background

GEI was retained by the TOP as a qualified local lake management consulting firm to continue lake management services concerning water quality in Putnam Lake, Hamlet of Putnam Valley, TOP, Putnam County, New York. Putnam Lake is a 225-acre lake located within the TOP. The lake has a north-south orientation and is relatively shallow, with a maximum depth of 16 feet in the southern section of the lake. Most of the lake is less than 12 feet deep. Historically Putnam Lake has recorded max depths of 17 or 18 feet but nothing deeper than 16 feet was observed in 2023. Putnam Lake has experienced consistent significant harmful algae blooms (HABs) and excessive aquatic plant growth including Aquatic Invasive Species (AIS) such as curly leaf pondweed (*Potamogeton crispus*), water chestnut (*Trapa natans*), brittle naiad (*Najas mino*r), and Eurasian watermilfoil (*Myriophyllum spicatum*).

Dredging is one of the proposed methods to remedy localized aquatic plant growth, remove phosphorus, and improve in-lake navigation. While dredging may achieve these lake improvement goals, implementing a dredging program can be complicated and requires state and federal permits and significant regulatory agency coordination. Before starting a dredging project, steps must be taken to ensure that accurate information is obtained and that the project does not hit any avoidable roadblocks. Taking an iterative, phased based approach to dredging helps maximize appropriate expenditures and increase the likelihood of success. GEI's 2023 scope included a phased approach to determine feasibility and permitting requirements. In addition, an estimate of how much phosphorus will be removed by dredging was determined.

Pre-Application Meeting with NYSDEC

On November 28, 2023, GEI staff and TOP representatives met virtually with New York State Department of Environmental Conservation (NYSDEC) to discuss the potential dredging project for

Putnam Lake. Pre-application meetings may not provide clear resolutions for projects, but they allow an opportunity for the permit applicant to directly interact with the agency to better understand permitting pathways and NYSDEC recommendations. These meetings help to establish future considerations for work and how to get things permitted and approved as efficiently as possible. GEI summarized the project discussing dredging feasibility, phosphorus reduction, sedimentation issues, and how dredging could address ongoing AIS management issues. Topics discussed included:

- Dredge material disposal.
  - Would the material have to be moved offsite? If moved offsite, the volume of removed sediment would have to be predetermined.
- Chemical and physical testing requirements would need to occur related to solid waste regulations or beneficial uses. A sediment sampling plan will need to be approved by NYSDEC. There may be some exceptions made for navigational dredge materials on a case-by-case basis.
- Dredging can be done in phases to reduce impact and cost of project over time.
- To get permit approval there needs to be a strong justification for dredging and project details need to be provided.
  - Is sediment having adverse impacts on the waterway?
  - Why are certain dredge areas being chosen over other areas?
  - Existing bathymetry of the lake is needed as well as proposed depths after dredging.
  - Where will the sediment/dredge spoils be placed and how/where would the material be de-watered?
  - What water quality turbidity controls will be put in place to ensure minimal impact to the environment?
- Project is likely under United States Army Corps of Engineers (USACE) jurisdiction in addition to NYSDEC. Putnam Lake is also within a New York City Department of Environmental Protection (NYCDEP) watershed suggesting they may also have jurisdiction.
- State Environmental Quality Review Act (SEQRA) would have to be completed.

One key takeaway from the pre application meeting with the NYSDEC is the need for a strong justification for dredging in Putnam Lake. Since the technique can be highly destructive to the surrounding ecosystem, the benefits of the proposed project need to clearly outweigh any negative consequences. This is an additional consideration other than cost in terms of determining if dredging will be a feasible approach.

Proposed Dredge Areas

The TOP provided GEI with proposed dredge zones within Putnam Lake based on site observations (Fig. 1). The zones are distributed across the central/northern half of the lake starting from the cove north of S. Lake Drive and ending just north of Jackson Beach. Table 1 below describes each dredge area.

Table 1. Dredge Areas in Putnam Lake and Descriptions

Dredge Area	Description
1	Combination of cove area and lake-exposed area. Historical water chestnut growth in back of cove. The cove is home to the South Launch and Storage.
2	Lake-exposed area encompassing Warren Beach and north to Haviland Road. Most of this dredge area was deeper than 8 feet.
3	Area directly north of Jackson Beach. Mostly ~5 to 7 feet deep with areas closer to the middle of the lake averaging 10 feet. Uniform bottom with little defining features.
4	Area containing Willow Island. Water depths are particularly shallow around the island itself and directly north and south.
5	Northernmost section of the lake. Mostly under 6 feet of water with a significant water chestnut infestation in the shallower waters. Direct access to the North Launch and Boat Storage and the Johnson Beach Park area. The northern inlet flows through a wetland and into this area.
6	Directly south of dredge Area 5. Water depths ranging from 5 to 8 feet with shoreline areas infested with Eurasian watermilfoil, filamentous algae, and duckweed.
7	Directly south of dredge Area 6, with deeper water depths and access to Hudson Beach Park Area. Plant communities are similar to dredge Area 6.
8	North of Willow Island, shallow water depths on shoreline (<3 feet). Inlet of one of the larger tributaries entering Putnam Lake present in this area.
9	Mostly lake-exposed shoreline area containing the Interlaken boat storage and park area. Mostly deeper waters with limited area for plant growth.
10	Lake-exposed area with shallower cove. Sporadic large boulders were present in both main dredge area and cove section. Southern end contains Parma Boat storage. Cove is the end point to a small inlet that drains the Knox, Kenton, and Gates Road area.

The dredge areas varied widely with respect to main lake exposure, on shore development, aquatic plant community, and relative water depths. All areas had water depths deeper than 10 feet at the outermost, lake-facing sides except for Areas 5 and 6.

Sediment Depth Probing

GEI conducted a sediment probing study inside of potential dredge areas within Putnam Lake on November 8, 2023. Staff set a predetermined number of points within each dredge area to evaluate sediment depth at each individual point (Fig. 2). This was completed utilizing ESRI Field Maps and a sub-meter GPS Unit (Trimble TDC650) to navigate to each point on the lake. Once at a point, staff used a 12-foot aluminum pole with inch markings and lowered to the bottom of the lake until reaching the top layer of sediment. That depth was recorded and then the pole was thrust downward until reaching the first layer of refusal, which is presumed to be bedrock, bare earth, or another impenetrable material which represents material that would not be dredged. The first depth was subtracted from the second depth to provide an estimated amount of dredge material to be removed at that point (Table 2).

Table 2: Minimum, maximum, and average sediment depths assessed in Putnam Lake.

Dredge Area	Minimum Sediment Depth (ft)	Maximum Sediment Depth (ft)	Average Sediment Depth (ft)
1	0	2.9	1.5
2	0	2.3	1.1
3	0.1	2.4	1.4
4*	N/A	N/A	N/A
5	0.3	3.8	2.1
6	0.7	2.3	1.6
7	1	1.9	1.5
8	2.5	2.6	2.6
9	0	1.2	0.5
10	0	2.8	1.2

*Area 4 was not sampled due to equipment malfunction and sufficient data in nearby areas. The area was also observed via boat and staff gained a perception of the sediment load in that manner.

On average, Areas 5 and 8 had the highest amount of sediment depth at 2.1 ft and 2.6 ft respectively. Areas 2, 3, 9, and 10 were all below 1.4 ft with the lowest average at Area 9 at 0.5 ft. The average sediment depth across all sites assessed was 1.5 ft. It is expected to see Area 5 have a high average sediment depth as it is near one of the major inlets of Putnam Lake. As water flows in from the inlet, it also carries sediment which is then deposited into Area 5.

One important observation is the water depth of many of these dredge areas. Most dredge areas outside of Zone 5 and 6 on their outside, lake facing side are deeper than 8 feet. Dredging in areas deeper than 8 feet is not impossible but requires more specialized equipment than normal lake dredging contractors may have. Ideally, these areas would be beneficial to dredge, especially the middle of the lake where phosphorus has accumulated and is contributing to internal loading and HAB blooms. Based on the difficulty of dredging these deeper water areas, GEI recommends that dredging be focused on areas less than 6 feet deep.

Based on the above assessment and analysis, GEI believes that Areas 1, 5, 6, 7 should be made priority dredging areas. Multiple factors go into this recommendation as outlined in Table 3.

Table 3: Dredge area assessment and factors considered for dredge site recommendations.

Dredge Area	Center of Recreation (Y or N)	Accessibility (Low/High)	AIS Management (Y or N)	Average Sediment Depth ≥ 1.5 ft (Y or N)	Potential for Phosphorus Removal (Low/High)
1	Y – Boat Launch	High	Y	Y	High
2	N	Low	N	N	Low
3	Y- Beach	Low	N	N	Low
4	N/A	Low	N	N/A	Low
5	N	High	Y	Y	Low
6	Y	High	Y	Y	Low
7	Y	Low	Y	Y	High
8	N	Low	N	Y	High
9	N	Low	N	N	Low
10	N	Low	N	N	Low

Centers of Recreation: Centers of Recreation are areas that are used by stakeholders and the public that could benefit from dredging. Another factor that was considered was if dredge operations would interfere with any forms of recreation. For example, if an area is dredged and spoils were required to be placed on a public beach, it would be assumed that the beach would not be accessible.

Putnam Lake does not allow gas motors, so there is not an immediate need to dredge navigation channels for boats. Most rowboats and canoes/kayaks can navigate in waters as shallow as 2 feet deep. Dredge Areas 8 and the northern section of 4 have really shallow sediments close to shore and around the island, however there are no boat access points nearby. GEI feels that the recreational argument for dredging is not as strong as some of the other arguments and should not be a focus of permitting efforts.

Accessibility: This considers the ability to access a potential dredge area as well as the distance traveled, or effort involved to move dredged sediment offsite. Certain areas have immediate and simple access with quick offloading areas while other areas are not ideal shoreline locations. It is also important to consider where removed dredge material can be dewatered before being trucked off-site. Accessibility of the site is directly related to cost, as there will be more labor time to move material 1,000 feet or more versus 250 or 500 feet.

Broadly speaking, Putnam Lake has four types of town access areas: boat launches, beaches, park areas, and boat storage facilities. Boat launches are the areas where a potential hydraulic dredge can be deployed and where a truck can access the lake to remove sediment. Beaches represent access areas potentially for trucks, such as Warren, but could also be an important dewatering location as well. Park areas around Putnam can potentially be dewatering areas or allow for the launch of smaller hydraulic dredges, however, most of the park areas do not have a significant amount of flat land, which complicates prospective use. Boat storage areas are often located next to other access points. Unfortunately, the largest boat launch area and a potential dewatering location, the Boat House, is located on the southern end of the lake, removed from the proposed dredge areas.

For dredging feasibility, the areas which make the most sense in terms of accessibility are areas that are in close proximity to the three boat launches, South Launch, The Boat House and Boat Storage, and North Launch. Dredge Areas 1, 2, 5, 6 and 7 are all in close proximity to these launch areas. Dredge Areas 2, 3, 5 and 6 are close to beach areas. Areas 5, 6, 7, 8 and 9 are close to park areas. Consistently, dredge Areas 1, 5, 6 and 7 are close to a lot of different town access points and therefore score highly on the accessibility assessment. Known access points are shown in Fig. 3.

AIS Management: There are multiple AIS known to exist in Putnam Lake that build up various reproductive structures within the sediment. Therefore, if sediment is removed from Putnam Lake via dredging, then the reproductive structures of the known AIS within Putnam Lake will also be removed. This does not mean these species will be eradicated, but it will significantly help in reducing their populations. Most of the decisions around AIS management in this analysis were based on populations of water chestnut, as reproduction via seed is the sole method of reproduction for the plant. Therefore, removing the seeds or “nutlets” would have a long-lasting impact on the population. While other AIS such as Eurasian watermilfoil and brittle naiad can reproduce via seed (with the latter being a more dependent seed grower) both can fragment and reproduce vegetatively. Hence, dredging might be locally effective for a short period of time, but the remaining plants outside of the dredge area will quickly re-populate those areas.

Dredging to a deeper depth can also limit light penetration to the lake bottom and restrict the areas a species like water chestnut can grow. While water chestnut has been known to grow in waters as deep as 9 feet, most of the dense, recreationally impeding populations grow in less than 5 feet. Taking an already infested area and increasing the depth just a few feet can be enough to limit future expansion into the area. Other AIS such as Eurasian watermilfoil would not be as affected by increasing the depth, as this species has consistently been found in depths greater than 10 feet.

GEI believes that for the most benefit for AIS reduction using dredging, water chestnut populations should be the focus. Dredge Areas 1 and 5 have large populations of water chestnut in the back of the coves.

Potential for Phosphorus Removal: Based on phosphorus data interpreted below (Table 4), we approximated whether removal of sediment in this area would be beneficial in limiting the release of nutrients into the water column. The total mass of phosphorus contained in the sediment to be removed was also considered, not just the total phosphorus concentration. For example, dredge Area 2 has a high concentration of total phosphorus in the sediment, but overall, the area has sandy soils from the beach and rocky outcrops moving north towards where Haviland Road directly abuts the lake. Dredging in this area would not effectively remove a lot of phosphorus as sand does not hold much phosphorus. Conversely, dredge Area 5 had the lowest total phosphorus concentration in the sediment but based on GEI staff's observations and the sediment probing data, the total area can be dredged effectively and a lot more phosphorus can be removed than an area like dredge Area 2, with limited suitable sediment to remove.

Phosphorus Sediment Sampling and Fractionation

GEI staff collected multiple sediment samples from Putnam Lake on November 27, 2023, to be analyzed for various forms of phosphorus. This was conducted to 1) evaluate whether or not phosphorus released naturally from the sediment within Putnam Lake is contributing to HABs and 2) estimate the total volume of phosphorus to be removed via dredging. Sediment samples were analyzed for total phosphorus and for various phosphorus fractions. Phosphorus fractionation is an analysis that examines what forms of phosphorus are present as it relates to their solubility or ability to release into the water column. Phosphorus in lake sediments are bound to a number of organic and inorganic particles. Some of these bonds are functionally permanent and keep the phosphorus in the sediment indefinitely. Commonly in the northeast, phosphorus bound to aluminum and calcium are permanently bound outside of unique situations. Phosphorus that is bound to iron or that is loosely sorbed onto particulates is likely to be released into the overlying water during the summer, when oxygen concentrations are low (for iron bound P). Phosphorus bound to organic matter is a bit of a wild card, as the labile portion can be degraded and released and the refractory portion is mostly stable.

To collect samples, an Ekman dredge was lowered to the lake bottom and used to collect sediment from the first 5 cm of the sediment and made into a composite sample from the deep location and three locations in the middle of the lake at a depth of approximately 12 ft. The first 5 cm of the sediment is the layer in which any potential forms of phosphorus would be released and become bioavailable, thus the focus on that limited depth. After samples were made into a composite, they were placed in double Ziploc bags with site labels and additional information and put on ice. All samples were shipped overnight to the Upstate Freshwater Institute (UFI) to be analyzed and were received on November 28, 2023. All samples were analyzed for total phosphorus and all fractionation samples were analyzed for the following:

- Moisture %
- Solids %
- Loosely sorbed phosphorus
- Iron bound phosphorus
- Aluminum bound phosphorus
- Labile organic phosphorus
- Calcium bound phosphorus
- Refractory phosphorus

Fractionation Results

Based on the results presented in Table4, the iron bound phosphorus is by far the largest fraction of phosphorus present in the deeper sediments. As mentioned previously this is because in anoxic, or low oxygen, environments like the bottom of lakes, iron bound phosphorus readily releases into the water column thus providing a bioavailable form of phosphorus. Putnam Lake is a system that partially mixes and can be stratified in some portions during the year. Larger and deeper lakes go through a stratification process in which different temperature waters create stratified “layers” with different densities. These layers then prevent any movement of nutrients until temperatures equalize and the lake mixes, which usually occurs in autumn and spring. Putnam Lake does not go through that type of process and transitions between being mixed and stratified multiple times during the year. This is due to wind and cold fronts creating uniform densities. This switching between stratified and mixed throughout the year is problematic for maintaining good water quality, as the phosphorus that is released from the bottom sediment can be immediately used for harmful algae growth. The shallow nature of lake allows the harmful algae to take advantage of close to 100% of the sediment released phosphorus. Phosphorus sampling locations are showed in Fig. 4.

Table 4. Phosphorus analysis including fractionation data from Putnam Lake.

Sampling Date	Sampling Area	TPP Sediment	Moisture %	Solids	Loosely Sorbed P	Fe Bound P	Al Bound P	Labile Organic P	Calcium Bound P	Refractory P
		(µgP/g sediment)	%	%	ugP/gDW	ugP/gDW	ugP/gDW	ugP/gDW	ugP/gDW	ugP/gDW
11/27/2023	Area 1	187.765	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 2	495.192	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 5	89.345	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 6	297.817	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 7	341.533	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 8	208.323	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 9	318.395	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	Area 10	338.831	NA	NA	NA	NA	NA	NA	NA	NA
11/27/2023	FRA-1	209.75	89.6	10.4	0.8	1174.2	301.8	504.2	121.8	2.5
11/27/2023	FRA-2	236.68	88.7	11.3	2.8	112.7	306.7	480	228.5	7.8
11/27/2023	FRA-3	206.46	92	8	4.6	4269.4	292.5	711.2	81.3	13.8
11/27/2023	FRA-4	375.62	89.2	10.8	6.1	2133.8	542.2	733.9	43.2	157.9

Dredge Areas 2, 7, 9 and 10 had the highest total phosphorus content in the sediments. Interestingly these areas are quite different from each other in terms of land use and lake location. It is important to note that sediments in lakes can be patchy in terms of their distribution of phosphorus. All the phosphorus samples taken outside of the fractionation samples were taken in ~5 feet of water depth. Sediment shallower and deeper may have different phosphorus content as well. Sandy soils will hold less phosphorus as compared to mucky soils.

To estimate the total amount of phosphorus that can potentially be removed from the dredge areas, GEI took the average sediment depth of each area and multiplied it by the surface area to get the average dredge volume. For dredge area 4, which did not have sediment probing data, GEI took the average sediment depth from each area and used that value as the average sediment depth. To calculate mass of the sediment, GEI estimated the bulk density of the sediment and multiplied this by the sediment volume. Bulk density was estimated based on previous studies of other lake sediment investigations (Sekellick et al. 2013) and laboratory communications and assigned a value of 0.64 g/cm^3 for all samples. Sediment mass was then applied to the total phosphorus concentrations to calculate the total amount of phosphorus in the sediments of each dredge area. Areas 3 and 4 were assigned the average of the sediment total phosphorus values taken across the lake.

Table 5 shows the total amount of phosphorus that can be potentially removed from the sediments of Putnam Lake within the set dredge areas. Dredge areas 8, 7 and 6 had the highest estimated phosphorus content with areas 9, 5 and 1 having the lowest phosphorus content. There are a few important caveats to note here with respect to these estimates. First, it is important to note that not all this phosphorus is available for algae use or can be accessed by rooted plants. If phosphorus is bound to refractory organic compounds like aluminum and calcium, plant and algae may not be able to access this type of phosphorus. Secondly, the total numbers presented below seem large and by extension, one would assume that dredging these areas would automatically remediate the lake. Sediments normally contain well over 10-100 times the phosphorus content as the overlying waters, therefore it should not be expected that this amount of phosphorus removal in the sediments will directly translate to decreases in the in-lake surface water total phosphorus concentrations on an annual basis. There is still an internal nutrient load, general stormwater inflows, and septic systems which will contribute to the in-lake surface water concentration.

Table 5. Total amount of phosphorus that can potentially be removed from Putnam Lake based on fractionation data.

Dredge Area	Acre Feet of Sediment	Average Phosphorus Concentration Dry Weight mg/kg	Mass of sediment (kg)	Total P in Dredge Areas (kg)
Area 1	10.5	1,878	8,287,775	15,562
Area 2	7.7	4,952	6,077,701	30,096
Area 3	9.8	2,850	7,735,256	22,045
Area 4	13.5	2,850	10,655,710	30,369
Area 5	15.75	893	12,431,662	11,107
Area 6	16	2,978	12,628,990	37,611
Area 7	15	3,415	11,839,678	40,436
Area 8	27.3	2,083	21,548,214	44,890
Area 9	3.5	3,184	2,762,592	8,796
Area 10	12	3,388	9,471,742	32,093

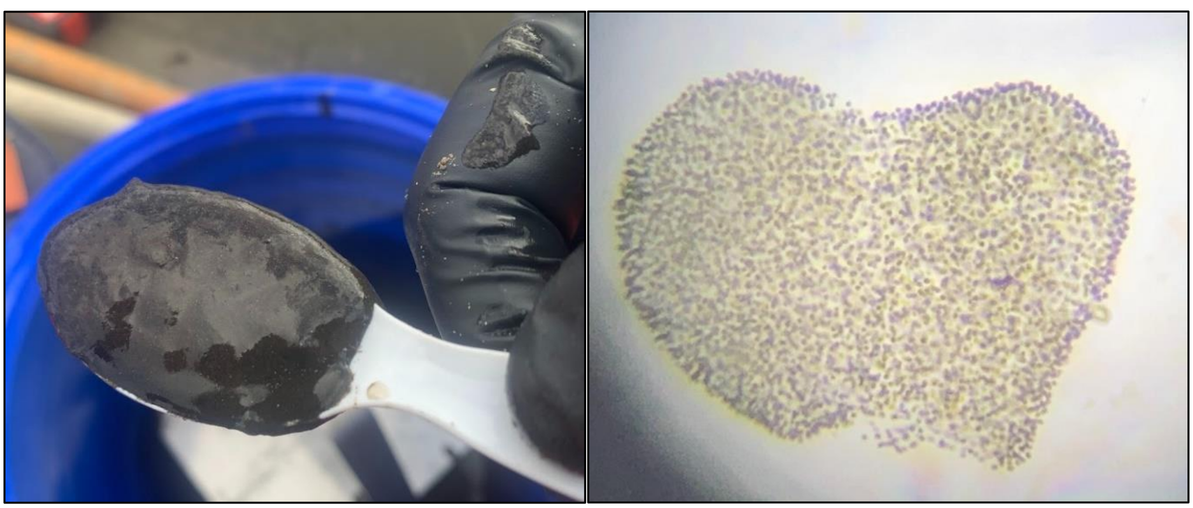
In terms of longevity of sediment accumulation, direct measures of sediment accumulation rates were not apart of the current scope of work, however from observations from the site visit, a few broad conclusions can be drawn. First, dredge areas with significant inlets to the lake such as areas 5, 8, and the back cove of 10 will likely gain depth faster than other areas that have direct drainage as large storm events will continue to push sediment from the watershed into these areas. Larger particles from storm events will settle closely to the entrance locations in the lake and as particle size gets smaller, the storm materials will travel further out from the initial entry point. This is not to say that other areas do not get watershed accumulation, as lake outfalls where catch basins dump into lakes will get some amount of sediment accumulation. Secondly, limiting plant regrowth in areas where dredging takes place will limit the amount of accumulated sediment as plants will not continue to grow and die in those areas. Third, sediment resuspension in lakes from storms and wave movement can influence where sediments are moved throughout the lake. Mapping out sediment movement patterns in lakes was not a scope of work item for this work.

Harmful Algae Blooms

During our sampling of the bottom sediments, a few locations, namely FR-1, FR-2 and FR-3 had evidence of cyanobacteria vegetative cells on the top of the mud sample. GEI took subsamples back to the laboratory for microscopic evaluation and confirmed the cyanobacteria Microcystis. Microcystis and other cyanobacteria have either vegetative cells or resting stages called akinetes that settle to the bottom of the lake after growing in the water column and overwinter on the sediment. Germinating in the spring and summer due to various factors, these resting stages are the start of many lake-wide blooms. In some lakes, sediment originating algae is one of the leading mechanisms behind algae blooms. It is unknown how widespread the vegetative cells are on the lake sediment bottom in Putnam Lake, as this was not the intended design of the study. Due to the history of severe, lake-wide blooms GEI believes it is likely that these vegetative cells are widely distributed.

Recently, there has been an increased focus on using algaecides to proactively manage HABs at the sediment-water interface early in the season. The idea is that if there is a significant amount of akinetes or vegetative cells in defined sediment areas, an early application of an algaecide to these areas can kill these cells before they have the chance to pop up and cause impacts. This may be a strategy to consider in the future for Putnam Lake, especially if HABs become more of an issue and interrupt recreation or cause ecological/health detriment.

Photo: **Right:** Sediment sample at FR-1 with small specs of cyanobacteria.
Left: Microscopic confirmation of *Microcystis* cells.



Preliminary Costing

Costing for dredging projects can vary significantly depending on the site-specific conditions. **Before engaging in a dredging project, site specific costs should be quoted by multiple experienced dredge contractors.** Costs presented in this section are approximates based on GEI's professional experience but may not represent actual costs for the project.

Site specific conditions, discussed throughout the report, but summarized below are as follows:

Amount of Sediment to be Removed: More sediment to be removed would equate to more labor time on the water and more labor time for removal.

Depth of Dredge Area: Dredging deeper waters requires specialized equipment, increasing costs.

On-Water Travel/Transport: The farther the dredge contractor has to travel to get to the dredge area and to the offload area for sediment can increase price.

Sediment Testing/Disposal Requirements: Results from the sediment testing to inform beneficial use may increase disposal costs, if there is an identified contaminant in the sediment testing.

Disposal of Material: If material needs to be moved offsite, costs can dramatically increase, sometimes doubling the total cost of the project.

Costs can have a wide range and are usually based on the cubic yards of material to be removed. For the following costing range table (Table 6), GEI assumes that hydraulic dredging would be the dredging technique of choice. Mechanical dredging, where a backhoe or a similar construction vehicle is staged on shore and used to removed sediment and place it directly onshore. Much of Putnam Lake's shoreline is not conducive to this type of removal, especially areas that would be a high priority for dredging. Hydraulic dredging involves a boat system that uses an underwater cutter that breaks down material and sends it through a pipe/tubing to an onshore location to be de-watered.

Table 6. Generalized costing for potential hydraulic dredge operations on Putnam Lake based on high priority sampling areas, cubic yards of sediment and low/moderate/high costing.

Sampling Area	Surface Area (Acres)	Depth of Sediment (Ft)	Cubic Yards of Sediment	Hydraulic Low ($10 Per Cubic Yard)	Hydraulic Moderate ($50 per Cubic Yard	Hydraulic High ($100 per Cubic Yard)
Area 1	7	1	11291	$112,910	$564,550	$1,129,100
Area 1	7	2	22582	$225,820	$1,129,100	$2,258,200
Area 1	7	3	33873	$338,730	$1,693,650	$3,387,300
Area 5	7.5	1	12098	$120,975	$604,875	$1,209,750
Area 5	7.5	2	24195	$241,950	$1,209,750	$2,419,500
Area 5	7.5	3	36293	$362,925	$1,814,625	$3,629,250
Area 6	10	1	16130	$161,300	$806,500	$1,613,000
Area 6	10	2	32260	$322,600	$1,613,000	$3,226,000
Area 6	10	3	48390	$483,900	$2,419,500	$4,839,000

Area 7	10	1	16130	$161,300	$806,500	$1,613,000
Area 7	10	2	32260	$322,600	$1,613,000	$3,226,000
Area 7	10	3	48390	$483,900	$2,419,500	$4,839,000

Based on Table, all scenarios for costing would be well over $100,000 for dredge costs. The three ranges of per cubic yard costs incorporate the site-specific challenges noted above. The first scenario, $10 per cubic yard of sediment is for the most ideal situations for dredging, where access to the site is close and dewatering and disposal can be done directly on shore. For these types of projects, costing can also increase based on permitting requirements, sampling requirements from the state for beneficial use and any on site restoration that needs to take place depending on the technique chosen. For these ancillary costs, the range of const increases can be anywhere from $20,000 to $100,000 more. **It is important to note that these costs are just ranges and GEI strongly recommends getting direct quotes from qualified dredge contractors for this amount of work.**

For Areas 1, 6 and 7, costs can be reduced by scaling back the amount of dredging to focus on the shallower, less than 6-foot sections.

Dredging Feasibility Summary

Dredging is an effective method in removing sediment that may be contributing to issues such as limiting recreational opportunities, release of nutrients feeding HABs, or harboring a seed bank for AIS. Although effective, dredging can be an extremely costly endeavor if not planned properly and getting all regulators or stakeholders from the outset of a project.

The below bullet points summarize the results and recommendations of the dredging feasibility analysis conducted in 2023.

- GEI recommends that the TOP investigate dredging operations in dredge Areas 1, 5, 6, and 7 with priority given to Areas 1 and 5 based on proximity to recreation, accessibility, and opportunities for AIS management and potential phosphorus removal.
- Dredge contractors should be contacted to provide accurate, site specific pricing for removal of sediment.
- If/when dredging occurs, it should be completed in a phased approach to limit interference with recreational opportunities. Based on GEI's knowledge of dredge operations and the pre-application meeting with NYSDEC, any removed sediment would have to be de-watered before being moved off site or placed in a final location.
    - During Area 1 dredging, the south boat launch will be occupied for dredge operations, but the north boat launch will be available for use. Any dewatering of Area 1 sediment could be theoretically done at Warren Beach. With this proposed approach, only one boat launch and beach area will be occupied at a given time. It is important to note that this will be subject to agency approval and the feasibility of storing that much material on land.
    - During Area 5, 6, and/or 7 dredging, the north boat launch will be occupied for dredge operations leaving the south boat launch available for use. Any dewatering of the Area 5, 6, or 7 sediment could be done at the Hudson Beach Park area. As with the Area 1 approach, this will only occupy one boat launch or beach area at any given time and limit distance traveled for operations.

- If dredging is not chosen as a viable alterative for the TOP, GEI highly recommends investigating other in-lake methodologies to reduce phosphorus and/or HABs. Methods such as targeting the akinetes with a peroxide herbicide or oxygenation should be given greater consideration.

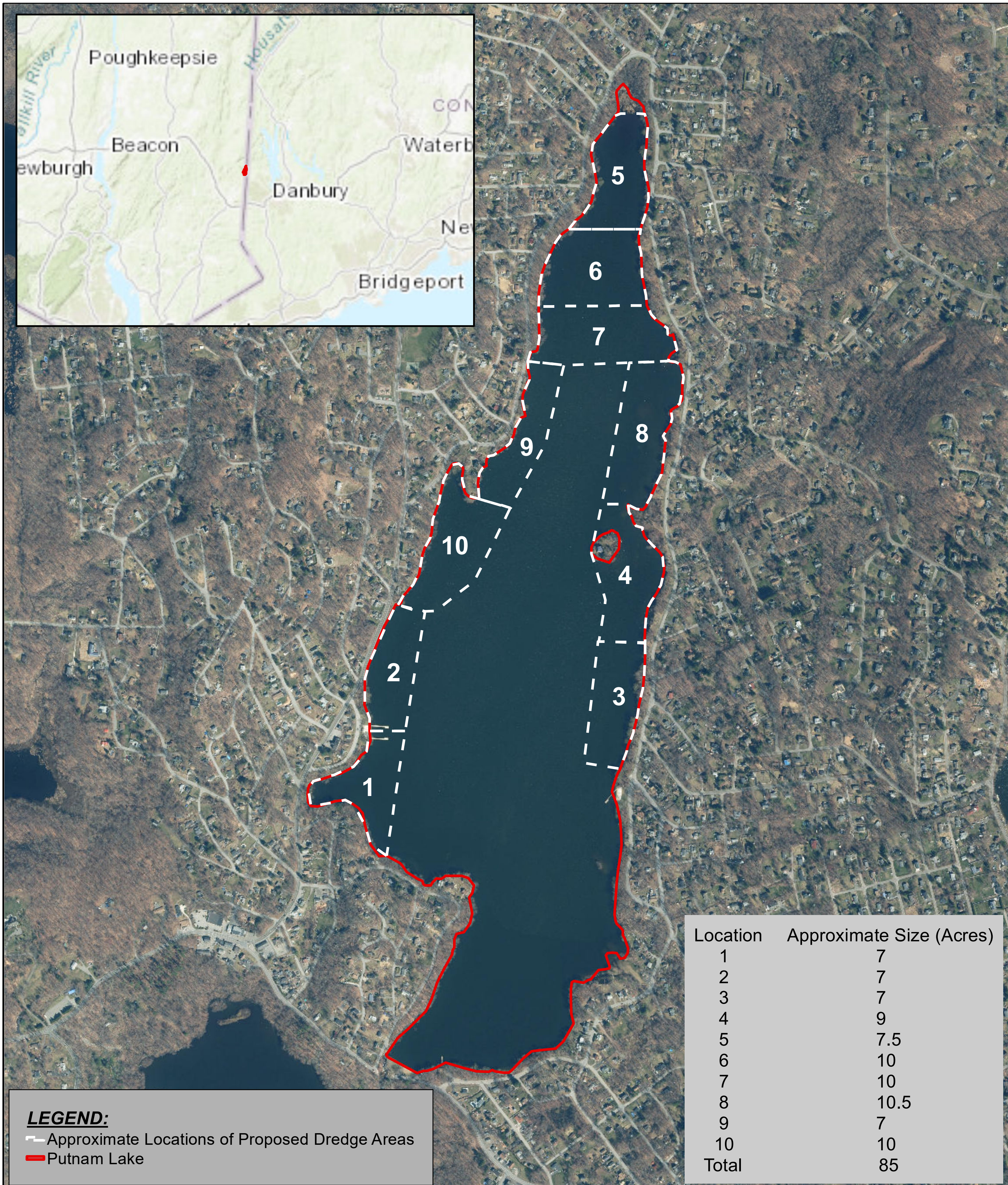
References

Carey, C.C. and Rydin, E., 2011. Lake trophic status can be determined by the depth distribution of sediment phosphorus. Limnology and oceanography, 56 (6), pp.2051 2063.

Sekellick, A.J., Banks, W.S.L., and Myers, M.K., Jr., 2013, Water volume and sediment volume and density in Lake Linganore between Boyers Mill Road Bridge and Bens Branch, Frederick County, Maryland, 2012: U.S. Geological Survey Scientific Investigations Report 2013–5082, 15 p.

Figures

Appendix 1
Phosphorus Sampling Report



Location	Approximate Size (Acres)
1	7
2	7
3	7
4	9
5	7.5
6	10
7	10
8	10.5
9	7
10	10
Total	85

Putnam Lake Dredging Feasibility Study
Putnam Lake, Town of Patterson
Putnam County, New York

Town of Patterson

0 1,000 2,000
SCALE: 1" = 1,000'

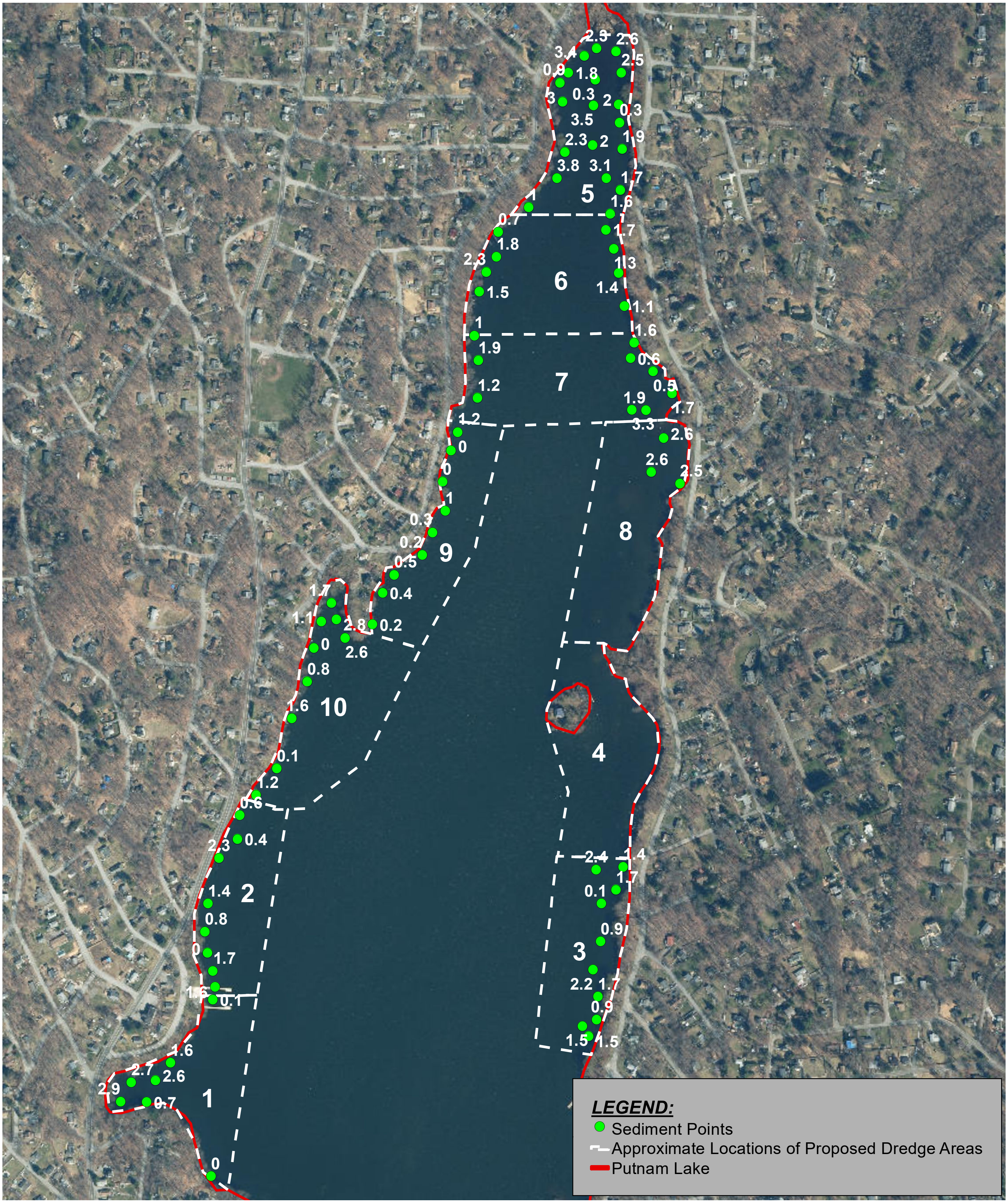
GEI Consultants

Dredging Feasibility

Project: 2303651 Figure: 1

October 2023

B:\Working\PATTERSON NY, TOWN OF\2303651 Putnam Lake Dredging Feasibility Study\05_GIS\MXD\2303651 Location Map 8.5x11.mxd
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS,



Putnam Lake Dredging Feasibility Study
Putnam Lake, Town of Patterson
Putnam County, New York

Town of Patterson

0 650 1,300
SCALE: 1" = 650'

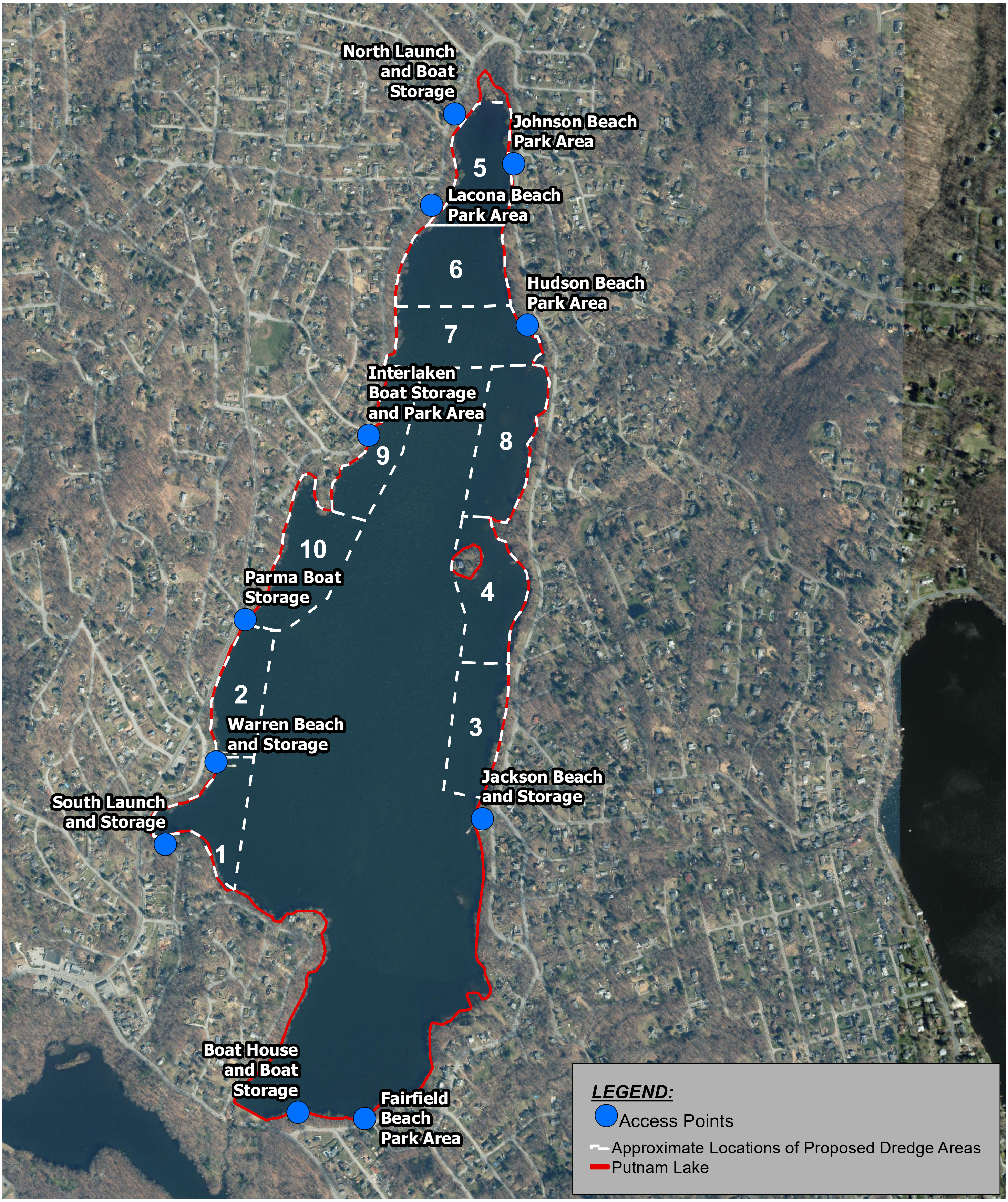
GEI Consultants

Dredging Feasibility

Project: 2303651 Figure: 2

April 2024

B:\Working\PATTERSON NY, TOWN OF\2303651 Putnam Lake Dredging Feasibility Study\05_GIS\MXD\2303651 Sediment Depths.mxd
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Putnam Lake Dredging Feasibility Study
Putnam Lake, Town of Patterson
Putnam County, New York

Town of Patterson

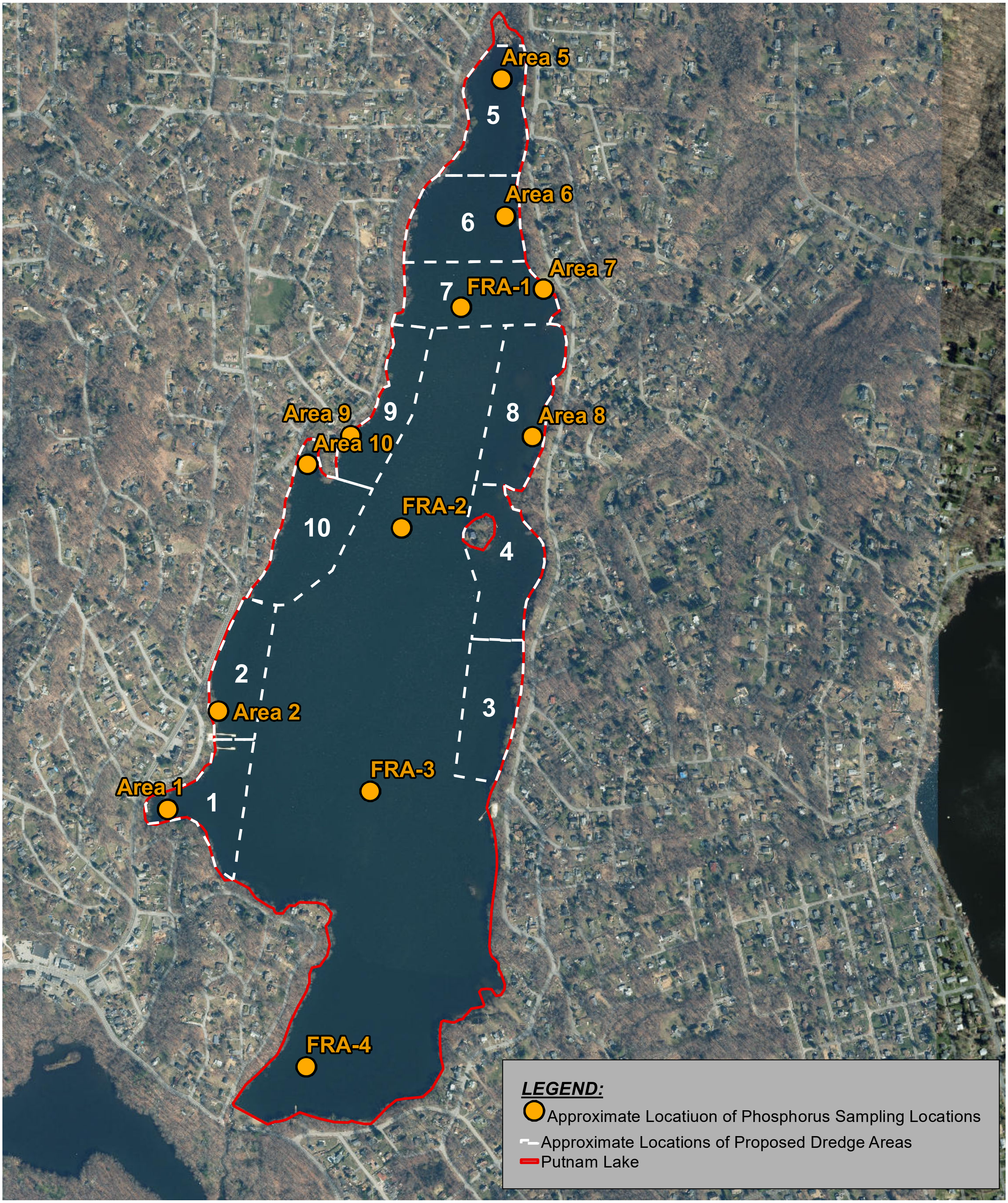
GEI Consultants

Dredging Feasibility Access Points

Project: 2303651 Figure: 3

April 2024

B:\Working\PATTERSON NY, TOWN OF\2303651 Putnam Lake Dredging Feasibility Study\05_GIS\MXD\2303651 Access Areas.mxd
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Putnam Lake Dredging Feasibility Study
Putnam Lake, Town of Patterson
Putnam County, New York

Town of Patterson

0 900 1,800
SCALE: 1" = 900'

GEI Consultants

Phosphorus Sampling Locations

Project: 2303651 Figure: 4

April 2024

B:\Working\PATTERSON NY, TOWN OF\2303651 Putnam Lake Dredging Feasibility Study\05_GIS\MXD\2303651 Sediment Depths.mxd
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Data Report Number: CHM2024_002
Putnam Lake Dredging Feasibility Phosphorus Report
Sampling Receipt Date: 11/27/23
Report Submission Date: 1/10/24

Prepared for:

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GEI Consultants
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Submitted by:

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Laboratory Director
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UFI Lab ID	Client ID	Station Name	Depth (cm)	Type	Sampling Date	Sampling Time	Receive Date	Receive Time	Comments log in	TPP (µgP/g sediment)	flags (TP)	Moisture %	Solids %	Loosly Sorbed P ugP/gDW	Fe Bound P ugP/gDW	Al Bound P ugP/gDW	Labile Organic P ugP/gDW	Calcium Bound ugP/gDW	Refractory P ugP/gDW
231128001-001	Putnam Lake	Area 1	5.0	Sediment	11/27/23		11/28/23	15:04		187.8		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-002	Putnam Lake	Area 2	5.0	Sediment	11/27/23		11/28/23	15:04		495.2		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-003	Putnam Lake	Area 5	5.0	Sediment	11/27/23		11/28/23	15:04		89.3		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-004	Putnam Lake	Area 6	5.0	Sediment	11/27/23		11/28/23	15:04		297.8		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-005	Putnam Lake	Area 7	5.0	Sediment	11/27/23		11/28/23	15:04		341.5		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-006	Putnam Lake	Area 8	5.0	Sediment	11/27/23		11/28/23	15:04		208.3		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-007	Putnam Lake	Area 9	5.0	Sediment	11/27/23		11/28/23	15:04		318.4		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-008	Putnam Lake	Area 10	5.0	Sediment	11/27/23		11/28/23	15:04		338.8		n/a		n/a	n/a	n/a	n/a	n/a	n/a
231128001-009	Putnam Lake	FRA-1	5.0	Sediment	11/27/23		11/28/23	15:04		209.8		89.6	10.4	0.8	1174.2	301.8	504.2	121.8	2.5
231128001-010	Putnam Lake	FRA-2	5.0	Sediment	11/27/23		11/28/23	15:04		236.7		88.7	11.3	2.8	1127.0	306.7	480.0	228.5	7.8
231128001-011	Putnam Lake	FRA-3	5.0	Sediment	11/27/23		11/28/23	15:04		206.5		92.0	8.0	4.6	4269.4	292.5	711.2	81.3	13.8
231128001-012	Putnam Lake	FRA-4	5.0	Sediment	11/27/23		11/28/23	15:04		372.6		89.2	10.8	6.1	2133.8	542.2	733.9	43.2	157.9

	Meaning of Flag
F3	Sample outside calibration curve
F6	Sample preserved upon receipt
F7	Sample received outside “acceptable” temperature limits
F8	Sample container inappropriate
F9	Sample container broken/cracked/leaked
F13	Data associated with failed duplicate
F14	sample received past holding time
F15	sample analyzed past holding time
F16	sample value between LOQ and the *LOD*
F19	No sample due to lab error
F20	No sample due to field error
F22	Sample value less than LOD
F23	Data associated with failed CCB
F24	Data associated with failed CCV
F26	Data associated with failed Matrix Spike
F27	Data associated with failed Matrix Spike Duplicate
F29	Data associated with failed Method Blank
F30	Data associated with Matrix Interference
F31	Data associated with a Method Deviation

[1]LOQ= Limit of Quantification [2]LOD= Limit of Detection

Parameter	LOQ[1]	LOD[2]	Method	Certified?	Date Calculated
TP*_auto	5.4 µgP/L	1.8 µgP/L	SM4500-P F-H, 2011	Yes	12/15/2022
TP_prep			SM4500-P B (5), 2011	Yes	
NOx*	30 µgN/L	10 µgN/L	SM4500-NO3 F, 2016	Yes	12/15/2022
NH3*	48 µgN/L	16 µgN/L	SM4500-NH3 H, 2011	Yes	12/15/2022
TN	159 µgN/L	45 µgN/L	SM4500-N C, 2011	N/A	12/16/2022
TSS	2.5 mg DW/L	1.0 mg DW/L	SM2540-D, 2011	Yes	published
ALK	20 mgCaCO3/L	20 mgCaCO3/L	SM2320-B, 2011	Yes	published
TDP*_auto	5.4 µgP/L	1.8 µgP/L	SM4500-P F-H, 2011	n/a	12/15/2022
SRP_manual	2.7 µgP/L	0.9 µgP/L	SM4500-P E, 2011	yes	12/15/2022
pH_L	exempt	exempt	SM4500-H+ B, 2011	n/a	exempt
Chloride_auto	3 mgCl/L	1 mgCl/L	SM4500-Cl E, 2011	Yes	4/20/2023
Specific Conductance	10 µS/cm	10 µS/cm	SM2510-B, 2011	Yes	published
Chlorophyll_fl	0.3 µgChl/L	0.1 µgChl/L	USEPA 445.0 REV. 2.0	N/A	published

*Samples filtered and or preserved upon receipt
NH3 samples not distilled prior to analysis

ELAP ID: 11462
Upstate Freshwater Institute Laboratory Report
Data Report Number: CHM2024_002
UFI Contract Number: 604
The attached samples were collected by GEI Consultants staff according to their methods.
Samples arrived on ice, in containers provided by the client.

The reported results are pertinent to the samples as they were received at the laboratory.
NS means no sample was received or requested.

Compiled by: Gina Kehoe (signature)
Gina Kehoe
Laboratory Director

Reviewed by: Gina Kehoe (signature)
Gina Kehoe
Laboratory Director

Date: 1/10/24